



The Beneficial Effects of Ramadan Fasting from the Medical and Sociocultural Perspectives

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ABSTRACT

Despite the abundant treatise and resource materials on Ramadan fasting, questions still arise regarding the benefits of this annual religious ritual. In an attempt to lend credence to the medical benefits of Ramadan, an academic adventure was undertaken, entailing the principles of Ramadan fasting and its effects on Muslims in terms of health and sickness. The findings of the studies on the health implications of Ramadan fasting and other similar prolonged dietary restrictions in human participants and animal models were reviewed and discussed. This review also catalogued the main contributions of fasting to the human health and physiological wellbeing of experimental subjects. In addition, our study considered religious limitations, as well as the side-effects and health hazards of some ailments that could pose a threat to Muslims, vis-à-vis their observance of Ramadan fasting. Some of the conditions that are inimical to the physiological status of human participants include cardiac diseases, diabetes mellitus, and pregnancy in women. Consistent with the previous findings, the present study indicated that Ramadan fasting has health, social, moral, environmental, and spiritual benefits for Muslims. In conclusion, fasting has proven an efficacious nutritherapy as the offered dietary regimens are among the non-pharmacological approaches to improving the human health with several societal and environmental benefits. In addition, Ramadan fasting leads to positive changes in the attitudes of individuals, thereby resulting in the sociocultural balance of the community and environmental harmony.

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Introduction

Fasting is one of the five pillars of Islam [1]. The meaning of fasting (*Sawm*) in Islam is to 'stop' or 'refrain from' and implies abstinence from eating, drinking, and sexual intercourse with the spouse while fasting in the holy month of Ramadan [2]. Fasting is prescribed for Muslims as an instrument of spiritual development [1, 2]. The religious literature abounds on the contextual meaning and conceptual value of Ramadan fasting [2-5]. Despite the abundant religious treatise and discussion of various topical issues on fasting at several forums [1-6], questions continue to arise at annual Islamic and other gatherings [7-10] regarding the concept of this one month-long religious exercise and its implications on the human health. In this review, we attempted to elaborate on the principles of Ramadan fasting [1-3, 6], vis-à-vis various conclusions emanating from the experimental

studies [11-19] and clinical trials on fasting [11, 20-25] in order to lend scientific credence to the medical benefits attributed to Ramadan fasting [7-11, 17, 23, 26-29]. In addition, we reported the anthropometrical and physiological parameters [11, 12, 15] and biochemical [11, 17, 26, 30], hematological [11, 15, 17], and health indices [15, 17, 27-29] obtained in fasting to attest to the health status of human participants. Some of these indices include the body weight, height, body mass index (BMI), packed cell volume (PCV), hemoglobin (Hgb) concentration, mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), red blood cell (RBC) count, white blood cell (WBC) count, color index (Hgb:RBC ratio), total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL), erythrocyte sedimentation rate (ESR), blood glucose level, atherogenic/atherosclerotic index, coronary risk

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index, and TC-to-HDL ratio (CRI, a measure of the risk of susceptibility to cardiac ailments). Furthermore, the present study aimed to examine some body systems [11, 19, 24, 30] and disease symptoms [7, 20-23, 25], which could be improved through fasting and document the cases of some patients [7, 20-23, 25, 31] that may benefit from fasting, including those with the disorders of the gastrointestinal tract (GIT), cardiovascular system, nervous system, anemia, hypersensitivity/allergic reactions, cardiac diseases, and diabetes mellitus. Therefore, the main objective of this review was to collate and present the documented findings in various treatises on the beneficial medical, sociocultural, and environmental effects of Ramadan fasting on various health conditions.

Principles of Ramadan Fasting

Ramadan fasting is observed by Muslims worldwide from eating a meal at dawn (*Sahur*) until fast breaking at sunset (*Iftar*) in religious parlance [1-3, 6]. In essence, the period of fasting lasts 10-18 hours daily depending on the geographical location and season of the year. Fasting continues for 29-30 days in Ramadan (9th month of the Islamic calendar) based on the visual sighting of the new moon (lunar calendar), with the firm intention of carrying out the orders of Allah [2]. Ramadan fasting is compulsory for all matured, healthy Muslim males and females, with the exception of the elderly, underage, travelers on long journeys, ill individuals, nursing mothers, and menstruating and pregnant women [2, 6]. As it is expatiated by an Islamic scholar, the exemption of travelers from fasting is applicable to those who may not be able to cope with the additional hardships of the journey while fasting [6].

The other prerequisites of fasting are mental and physical health, the lack of which qualifies an individual for exemption as further justified by medical explanations and physiological concepts [4]. As a prerequisite for Ramadan fasting, physical health entails the presence of complete and stable mental and psychological health, as well as a well-coordinated state of mind [6, 32]. According to the medical guidelines on fasting issued by the Islamic Medical Association of South Africa, ageing or senility entails the loss of strength and vigor, and elderly and feeble individuals may not fast [32]. However, they have to pay *fidiya* (feeding one poor person) for each day that they have missed their fasting duty [2].

Similarly, long-distance journeys cause fatigue and exhaustion, and such travelers are temporarily exempted from the annual exercise of fasting [6]. The rationale behind the exemption of ill individuals from fasting is also hinged on the requisites of normal mental and physical capabilities, as well as the restorative functions of the body prior to fasting [4, 6, 32]. Therefore, those who lack such requirements may be exempted from fasting. For instance, an individual suffering from an acute or chronic disease resulting in the progressive deterioration of health may lack the capability to cope with the physical challenges of fasting [31, 32]. In addition, any diseased state that requires frequent medication and the monitoring of patient's condition could compromise the fulfillment of 10-18 hours of obligatory daily fasting. However, an individual suffering from chronic conditions such as asthma [31, 32], diabetes [7, 33-35], hypertension [36, 37], epilepsy [31, 32], cardiac diseases [21-23, 25], and renal insufficiency [26, 31] may fast, provided that the condition is adequately curtailed by medication which should also be devoid of interference with the scheduled fasting period [31, 32].

Therapeutic measures such as medical injections, inoculations or vaccinations do not nullify the fasting of a Muslim patient [1, 6]. However, if an injection is used for nutritional purposes (e.g., intravenous infusion), fasting will be nullified. On the same note, procedures such as intraperitoneal injection, nasal feeding, and rectal feeding nullify the fasting of the patient. Notwithstanding the clarification in the foregoing rules about medical injections and inoculations, it is better to avoid these measures while fasting, provided that such avoidance will not aggravate the illness [2, 6, 32, 38].

The female gender is another important condition of exemption from fasting, which covers lactating, menstruating, and pregnant women [2, 6]. However, a nursing mother who is healthy, has sufficient milk to breastfeed, and is convinced that no harm will befall her newborn should fast. If lactation or milk production is adversely affected by fasting, women should temporarily avoid fasting [1, 32]. The choice to fast or not by nursing mothers during the holy month of Ramadan appears to be at the personal discretion of the individuals as clinical trials have indicated that fasting is injurious neither to nursing mothers nor suckling newborns [31].

According to Bener et al. (2001), fasting by nursing mothers during Ramadan does not change the composition of breast milk [27]. The monthly course of menstruation and the state of pregnancy are often associated with physiological changes and psychological challenges in women [11, 12], and it is imperative for these women to abstain from fasting during the menstrual period [31, 32]. As such, women experiencing severe symptoms of pregnancy (e.g., nausea, vomiting, heartburn) or those with the concern that fasting may be harmful to the living or unborn baby should not fast [31], and fasting must occur at a later date [2, 6]. One should comply with this medical advice since any factor that may adversely affect the health of a pregnant woman could also be detrimental to the unborn infant [32]. However, if pregnant women are able to cope with the physical challenges, metabolic demands, physiological constraints, and rigors inherent in Ramadan fasting [2, 31] and there is no risk of hindering the embryological development and healthy growth of the unborn, they should opt for fasting [1-3, 6]. Individuals with mental disorders are also exempted from fasting until they regain sound judgment [5, 6]. Fasting is a conscious act that requires the proper functioning of the physical and mental faculties. Therefore, those with severe mental retardation or any form of psychosis are exempted from fasting [31, 32]. Notably, omitted fasting (*Qada*) should be observed in lieu of the number of the days that are missed by any category of the exempted individuals mentioned earlier as soon as the condition that negates fasting abates [1-6].

Physiological Effects

The observance of month-long food restriction, especially as it entails the skipping of the afternoon meal and other intermittent food [2], could serve as a resting period for the GIT system [39], which is engaged in the constant metabolism of food particles and absorption of nutrients [30]. Since food consumption during Ramadan is restricted to two daily meals [6], the long hours of fasting could serve as a relief to the GIT cells and the entire gastrointestinal system [39] through a physiological rest [12, 28]. As soon as *Iftar* is taken, the body begins to build the important components of the cells and replenishes the stored substances that were used in the energy production during the hours of fasting [28].

The avoidance of food during long fasting hours could pose some challenges to metabolic activities and the growth of individuals [12, 30]. However, previous experimental studies have demonstrated that the restriction of food and water intake does not hinder growth [12]. In a clinical trial by Ajibola (2007) conducted on 30 male medical students observing Ramadan fasting, the BMI (<20 kg/m²) showed that the participants maintained very healthy weight throughout the study [15]. The report further indicated that the few participants that suffered insignificant, transient weight loss regained their weight after the expiration of the fasting exercise, which confirmed their healthy status [26]. On the same note, the human participants in other similar studies have not been reported to experience declined growth as their anthropometry (body weight and BMI) after fasting did not differ from the pre-fasting values [11, 12, 27, 31].

Hematological and Respiratory Functions

Several studies have indicated that Ramadan fasting does not pose any threat to the hematological and respiratory functions of the body [11, 12, 26-28, 31]. These beneficial attributes of Ramadan fasting have been confirmed by several studies in different climatic regions, as well as the clinical findings of Ajibola (2007), which demonstrated that Ramadan fasting has no adverse effects on physiological and hematological parameters [15]. Accordingly, the hematological values of the male participants observing Ramadan fasting were within the normal range before, during, and after Ramadan fasting. These parameters included hematocrit, PCV, Hgb concentration, RBC count, WBC count, MCHC, and MCV. The mentioned study also indicated that the color index of the human participants was within the normal range of 0.9-1.1, which is an indication that the symptoms of anemia did not arise during the clinical trial. This observation has been further endorsed by Chamsi-Pasha and Ahmed (2004) in their study regarding the effects of Ramadan fasting on patients with cardiac diseases [21]. Similarly, previous findings have documented that Ramadan fasting is not inimical to the pulmonary function or any respiratory activities [22-24], and no significant changes occur in the parameters constituting the measured spirometry during Ramadan fasting.

Biochemical Effects

It is a common observation that the fat stores in the body are depleted during food denials, dietary restrictions, and nutritional deprivation in animal subjects [13-19] and human participants [11, 12, 26, 29, 39]. Unlike unregulated food restrictions, the annual Muslim ritual of month-long intermittent fasting is associated with immense health benefits [28, 31]. In fasting, the serum levels of ketogenic substances increase significantly, thereby forming a major source of energy in the body through fatty acid oxidation and sparing glucose from the energy expenditure [40]. This contributes to the burning of excess fat in the body, which is an advantage to the individuals desirous of shedding excess body weight [41].

Therefore, fasting becomes a veritable tool for the regulation of the lipid profile of the body [42, 43]. This biochemical aspect of the health benefits associated with Ramadan fasting has been documented by previous studies as well [15, 17]. According to Ajibola et al., (2009) long-term intermittent fasting could decrease the serum levels of LDL-cholesterol (bad cholesterol) and increase HDL-cholesterol (good cholesterol) during Ramadan compared to the pre-Ramadan and post-Ramadan values [17] (Table 1). LDL transports cholesterol from the blood to the peripheral tissues, while HDL transports cholesterol from the peripheral tissues and intestines to the liver for metabolism and excretion [30].

Table 1. Health indices of human participants measured before (pre-) Ramadan, during Ramadan, and after Ramadan fasting from various studies (Means \pm SD).

Health index	Pre-Ramadan	Ramadan	After Ramadan	References
Body weight (kg)	57.40 \pm 5.15	55.40 \pm 5.28	57.25 \pm 5.41	[15, 26, 52]
Body mass index (kg/m ²)	19.41 \pm 1.77	19.08 \pm 1.87	19.34 \pm 1.58	[15, 26, 52]
Haematocrit (%)*	44.10 \pm 1.29	42.70 \pm 1.16	41.80 \pm 0.92	[15, 26]
Haemoglobin conc. (x10g/L)	14.28 \pm 0.20	14.11 \pm 0.11	14.09 \pm 0.18	[15, 26]
Erythrocytes count (x10 ¹² /L)*	4.89 \pm 0.10	4.77 \pm 0.09	4.52 \pm 0.17	[15, 26]
Leucocytes count (x10 ⁹ /L)	4.62 \pm 0.42	4.67 \pm 0.42	4.61 \pm 0.43	[15, 26]
MCHC (x10g/L)	34.00 \pm 0.82	32.67 \pm 1.10	31.20 \pm 0.63	[15, 26]
Mean Corpuscular Volume (fL)*	90.21 \pm 1.98	89.54 \pm 2.32	92.50 \pm 3.41	[15, 26]
Colour index	1.01 \pm 0.02	1.03 \pm 0.04	1.10 \pm 0.00	[15, 26]
Sedimentation rate (mm/hr)	3.20 \pm 0.63	3.20 \pm 0.58	3.00 \pm 0.67	[26]
Blood glucose level (mmol/L)	6.16 \pm 0.72	5.16 \pm 0.35	5.34 \pm 0.57	[50, 52]
Triglycerides, TG (mmol/L)	6.11 \pm 2.28	4.86 \pm 1.50	4.93 \pm 0.85	[50]
Total cholesterol, TC (mmol/L)*	8.01 \pm 1.06	7.43 \pm 0.91	7.61 \pm 0.80	[44, 50]
Low density lipoprotein (mmol/L)*	4.01 \pm 0.72	3.68 \pm 0.70	3.71 \pm 0.64	[44, 50]
High density lipoprotein (mmol/L)*	2.38 \pm 0.68	2.74 \pm 0.58	2.75 \pm 0.52	[44, 50]
Atherosclerotic index (LDL/HDL)*	1.77 \pm 0.48	1.38 \pm 0.44	1.40 \pm 0.44	[44, 50]
Coronary risk index (TC/HDL)*	3.53 \pm 0.84	2.79 \pm 0.58	2.85 \pm 0.63	[44, 50]

MCHC – mean corpuscular haemoglobin concentration; *Significant changes in variables during Ramadan relative to pre-Ramadan and after Ramadan (P<0.05).

Table 1 shows other changes in the lipid profile, anthropometric indices, biochemical indices, hematological parameters, and physiological measurements constituting the health indices of human participants measured before, during, and after Ramadan fasting. Notably, the health indices of human participants have been reported to improve by Ramadan fasting (Table 1). On the other hand, the reduction in the values of atherosclerotic index (AI) and CRI during Ramadan fasting is considered beneficial in the case of cardiac patients and susceptible individuals for these disorders who actively participate in Ramadan fasting [17, 21, 25, 44]. The AI and CRI indices further confirm the findings regarding the improvement of cardiac disorders as discussed earlier.

Fasting Patients

Prolonged fasting may exacerbate adverse health conditions [15]. A fasting period that exceeds 18 hours results in the pathogenesis of ketosis [25], which is confirmed by the observation of ketosis in the clinical trials involving diabetic patients after 32 hours of experimental fasting [20, 45]. The accumulation of ketone bodies is due to the burning of excess fats and the capability of the body to handle the by-products [46]. However, in most parts of the world, the month-long annual ritual of food and water restrictions observed by Muslims are limited to approximately 14 hours daily depending on the geographical location and season of the year [5, 11, 12, 15, 26-29, 35, 39, 47], which is in conformity with the principles of Ramadan as not to impose hardship on

participants, but rather, entail ease through fasting [2] as do the other Islamic duties [6]. In this regard, Ismail et al. (2011) lend scientific credence to this fact in their clinical trial on pregnant diabetic patients observing Ramadan fasting [33]. Similar reports were later published to note that fasting does not pose any risks to patients with diabetes mellitus and other metabolic diseases and may even be rather beneficial to these patients [7, 42]. Some of the health benefits of fasting for diabetic patients include the reduction of blood glucose [40], increased breakdown of glucose [42], reduced insulin production [40, 46], and increased glucagon production [42, 46] to facilitate the metabolic breakdown of glucose (glycolysis) [30, 33, 40, 42]. These findings are consistent with the clinical trial conducted by Azizi (2010) regarding the health implications of Ramadan fasting in diabetic patients [31]. Accordingly, Ramadan fasting is safe for all healthy individuals, as well as those with diseases such as diabetes mellitus. Nonetheless, those feeling unsafe should consult their physicians and follow scientific recommendations.

In another study carried out on the pregnant women with diabetes mellitus, their capability to fast was ascertained by evaluating their efficiency of blood glucose control during Ramadan, and a significant reduction was reported in the biochemical parameters of

HbA1c and fructosamine measured before Ramadan compared to the values obtained after Ramadan [33]. In addition, insulin requirement was observed to increase from the first until the fourth week of Ramadan, while the daily insulin requirement decreased before Ramadan (40U/day) compared to after Ramadan (38.5U/day). Nonetheless, most of the patients were able to complete fasting for 30 days (79.2%) without maternal or fetal complications [33].

According to the aforementioned studies, patients with various diseases could still fast without aggravating their health conditions [21, 25, 33, 47]. Table 2 shows the listed reports on patients benefiting from Ramadan fasting by different authors in different geographical locations. In a study conducted on cardiac patients, no significant changes were observed in the clinical chemistry values measured during Ramadan fasting [21]. Other prospective and retrospective studies conducted in Muslim-populated countries of Saudi Arabia and Kuwait have also denoted no significant difference in the incidence of cardiac diseases during Ramadan compared to the non-fasting periods of the year [22, 23]. Therefore, it could be inferred that fasting is not culpable in the pathogenesis of cardiac dysfunction, and patients with cardiac diseases could observe Ramadan fasting without experiencing detrimental health effects.

Table 2. Some patients that may benefit through their participation in Ramadan fasting.

Patients/Ailments	Effects of Ramadan fasting	References
Gastrointestinal disorders	Reduced HCl secretion; Enhanced metabolism; Physiological rest	[39, 41, 42, 43, 44]
Diabetes mellitus	Reduced blood sugar; Increased glycolysis; Reduced insulin production; Mobilization of ketogenic substances to replenish body energy; Increased glucagon production	[7, 10, 20, 30, 31, 33, 34, 41, 42]
Cardiac diseases	Decreased very low density lipoprotein; Decreased LDL-cholesterol; Increased HDL-cholesterol; Reduced athero-sclerotic index (AI); Reduced coronary risk index (CRI)	[21, 22, 23, 25, 40]
Overweight/Obesity	Burning of excess body fat; Weight loss	[41, 42, 43, 44]
Metabolic syndrome	Reduced blood sugar; Decreased triglyceride; Decrease total cholesterol; Decreased LDL-cholesterol; Increased HDL-cholesterol; Decreased very low density lipoprotein	[29, 43, 44, 56]
Renal diseases	Reduction in the occurrence of kidney stones	[31, 44, 61]
Eye defect	Amelioration of deteriorating effects of myopia	[47, 76]
Hypertension	Lowers systolic blood pressure; Reduction of day time blood pressure due to dehydration	[59, 60]
Hypersensitivity	Attenuates allergic reaction; Reduced anaphylaxis	[20, 48, 49]
Infertility	Improved female fertility; Extension of reproductive life	[28, 73, 74, 75]

Hypersensitivity/Allergic Reactions

According to the literature, fasting could improve other hazardous conditions, such as allergic reactions. In this regard, the findings of Nakamura et al. (2014) indicated that fasting could attenuate hypersensitivity [48]. In the mentioned study, rodent animal models were

exposed to food restriction in order to simulate human fasting and received a ketogenic, high-fat, low-carbohydrate diet, which accelerated fatty acid oxidation in the animals. This could further provoke the ketogenesis that had been stimulated by fasting [20]. These procedures were followed with a systemic anaphylactic

reaction induced by toluene 2, 4-diisocyanate to cause nasal allergies, and hypersensitivity was immediately abated by fasting. The allergic reaction was further monitored through the systemic instillation of D-beta-hydroxybutyrate, which is an anti-allergy agent. The findings of the mentioned study demonstrated that fasting could suppress the hypersensitivity reaction, and the increased level of D-beta-hydroxybutyrate by fasting played a key role in suppression of the allergic reaction through the stabilization of the mast cells. This is in congruence with the findings of Rahmani and Zarei (2003), indicating that Ramadan fasting could mitigate allergies [49].

Dehydration in Fasting

In an attempt to simulate human fasting, Ajibola et al. (2006a, b, 2007, 2009, 2010) subjected animal models to various degrees of water denial, which consequently reduced their feed consumption [13, 14, 16-19]. In two studies in this regard [14,19], experimental animals were subjected to 30% water restriction of their daily water intake, and those deprived of water for two days (three-day water deprivation regimen) thrived without dehydration. On the other hand, a few of the domestic mammals on five-day water deprivation that lost their body weight regained the weight promptly upon rehydration after the study [14, 19]. These field experiments on animals entailed intermittent water denials, which did not completely mimic Ramadan fasting

and could best be likened to intermittent human fasting.

There is a distinction between Ramadan fasting and intermittent fasting outside Ramadan as Ramadan fasting predicts total abstinence from fluid intake during the fasting period [2, 6], while intermittent fasting allows fluid intake [29, 39]. As a result, the individuals who observe Ramadan fasting may be exposed to the risk of dehydration. The adverse effects of dehydration could hinder productivity in the residents of extremely hot locations, as well as heavy duty workers or athletes [50, 51]. A review of the literature on the effects of dehydration on exercise performance indicated that dehydration by 2% or more of the body mass impairs the performance of aerobic exercises and may also degrade mental/cognitive function in thermally stressful environments [52]. The consequences of dehydration could also be grave in athletes as it has been well established that hypohydration could reduce physical performance [50]. However, the collation of the scientific literature comprising of laboratory, field, and clinical studies on the hydration status of human participants performing physical activities [15, 50, 51, 53-58] or during sedentary in the resting state [17, 24, 54, 59-61] have indicated insignificant or no changes during Ramadan (Table 3). In fact, the direct measurement of the total body water (TBW) content by some investigators has shown that TBW is chronically conserved in Ramadan fasting [58, 60, 61].

Table 3. Estimated mean hydration levels of some selected nationals during Ramadan.

Population	Sample	Hypohydration levels	Parameters measured	Reference
Nigerian Medical male students	18	No change	BM, Body fat	[17]
Physically active Nigerian males	27	No change	BM, Haematology	[15]
Physically active Gambian females	20	No change; but up to 7.6% (daytime)	BM, Body fat, Urine volume, Osmolality	[58]
Physically active Senegalese males	20	No change	BM only	[53]
Physically active Kuwaitis	6	<1.4%	BM, Serum osmolality, Sodium concentration	[54]
Tunisian Judokas	15	<10%	BM, Blood volume changes estimate	[51]
Tunisian Rugby players	9	No change	BM and Body fat	[55]
Tunisian footballers	55	No change; 2% exercise induced	BM, Urine SG, Serum biochemistry	[50]
Middle Eastern footballers	19	No change	BM only	[56]
French athletes	8	No change	BM, Body fat	[57]
Sedentary Kuwaitis	7	<1.3%	BM, Serum osmolality, Sodium concentration	[54]
Sedentary Pakistani males	46	No change	BM only	[24]
Sedentary Turkish people	7 males 37 females	No change	BM, Haematology Biochemistry	[59]
Sedentary Malaysians	13	No change; High urine osmolality (afternoon samples)	Urine volume, Osmolality, Solute excretion	[60]
Sedentary Indonesians	8	No change	TBW, BM	[61]

Apart from the challenges caused by dehydration to athletes, sportsmen, physically active individuals, and residents of warm and tropical areas, fasting individuals are at a high risk of the adverse consequences of dehydration. Some of the sequelae of dehydration include electrolyte depletion, hypercoagulation, and thrombus formation [62]. Thrombus formation could lead to the pathogenesis of ophthalmic vascular diseases, such as retinal vein occlusion (RVO) [63]. In fact, a clinical study on the pathogenesis of RVO in Saudi Arabia reported the increased incidence of RVO during Ramadan [64], suggesting that dehydration was culpable for the ophthalmic defects in these Arabian RVO patients.

Hypoglycemia in Fasting

The restriction of food intake is a known cause of hypoglycemia [34], which could become severe in diabetic patients [35]. Physicians often dissuade diabetic patients from fasting in order to avoid ketoacidosis due to hypoglycemia [28, 32]. In their recommendations for diabetes management during Ramadan, Al-Arouj et al. (2005) have stated that fasting could give rise to hypoinsulinemia and hyperglucagonemia, and this hormonal disequilibrium favors hyperglycemia, lipolysis, and the formation of ketone bodies, along with the development of diabetic ketoacidosis (DKA) [34]. As such, the risk of DKA may be higher during Ramadan. However, in the Epidemiology of Diabetes and Ramadan (EPIDIAR) study, which was conducted during Ramadan on 12,243 diabetics among the Muslim inhabitants of 13 countries in 2001, 42.8% of the patients with type I diabetes and 78.7% of those with type II diabetes managed to observe fasting for the mean duration of 23 and 27 days, respectively [35]. The mentioned study also indicated that the number of hypoglycemic attacks during Ramadan was low relative to the non-fasting months of the year, and this finding was attributed to undetected hypoglycemic states, reduced physical exercise, abstinence from certain drugs, and no blood glucose measurements [34]. Conversely, the study demonstrated severe hypoglycemic states causing hospital admissions to increase considerably, while no significant correlation was observed between hypoglycemia and ketoacidosis.

In another study on Libyan diabetic patients, no increase was reported in the incidence and

mortality of DKA during Ramadan, which is an indication that Ramadan fasting is not a significant risk factor for DKA [45]. The mentioned study also suggested that diabetics could fast safely during Ramadan without the increased risk of DKA. Similarly, the 2010 CREED study reported that 94.2% of the patients with type II diabetes mellitus enrolled in the study fasted for a minimum of 15 days, and 63.6% fasted every day [65] without reporting the complications of hypoglycemia. Nonetheless, the use of drugs by the diabetic patients who intend to fast during Ramadan should be properly monitored as different medications used in the management of diabetes mellitus may induce variable degrees of hypoglycemic risk [7, 20, 32]. In addition, these patients and their families should be thoroughly trained on diabetes management, vis-à-vis Ramadan fasting [31, 34], and their insulin doses and blood glucose levels should be properly adjusted and monitored while fasting [31, 33]. According to the Islamic Medical Association of South Africa [32], it is highly imperative that the medical guidelines on fasting be strictly adhered to.

Sleep Disturbances during Ramadan

Sleep is a vital indicator of general health and wellbeing. It has been postulated that an adult human requires an average of eight hours of sleep daily for healthy living [66]. The most basic physiological body components (e.g., body temperature, muscular activity, flexibility, and metabolic and psychomotor functions) have rhythmic variations that follow a circadian pattern [67]. These physiological processes (particularly metabolic and psychomotor functions) are greatly influenced by the quality and quantity of sleep. Ramadan dictates precise hours of restriction ranging from sunset to dawn [2, 3, 6], during which and in the attempt for more food intake [46], the hours of sleep are frequently altered [46], thereby leading to disturbances in the circadian or sleep-wake rhythm [67]. According to the literature, maintaining regular fasting intervals and eating in accordance with the normal daily circadian rhythms are essential to maintaining optimal metabolic function. Any deviation from these norms could lead to disruptive circadian rhythmicity.

Changes in sleeping patterns or habits may adversely affect health as metabolic and circadian processes are tightly linked. Some

observational studies have denoted that eating late at night is associated with reduced sleep duration and poor sleep quality [68, 69]. It has also been hypothesized that eating meals at abnormal circadian times (i.e., late at night) could lead to circadian desynchronization [70] and the subsequent disruption of normal sleep patterns. To the best of our knowledge, no studies have directly examined the association between fasting and sleep in adult humans. Apart from the sleep interruptions of having to wake up early in the day for *Sahur* (pre-dawn meal) [1-3], the circadian rhythm disruptions in humans during Ramadan fasting have been reported to cause no health hazards [26, 28]. Nonetheless, the few hours of sleep missed in lieu of *Sahur* could be compensated for with a siesta later in the day, presumably to complete the eight hours of the physiological requisite of sleep for adults.

Health Benefits

There are innumerable health benefits in Ramadan fasting [28, 31] as discussed extensively based on the findings and reports documented by several researchers in various regions across the world. In order to further demonstrate that Ramadan fasting is beneficial to health and also establish that it is devoid of health hazards, Ajibola (2007) conducted a 40-day clinical study on Muslim male participants fasting in Ramadan and measured their ESR periodically before, during, and after the fasting period [26]. ESR is known as the 'sickness index' and an independent predictor of certain diseases [44], which could be assessed through inexpensive laboratory tests to show RBC aggregation as an indication of blood viscosity [71, 72]. In the mentioned study, Ajibola (2007) reported no apparent signs of poor health in any of the participants during and after Ramadan [26]. In addition, the findings of this clinical study on 30 male participants revealed no changes in the ESR after Ramadan fasting ($P=0.44$) compared to the beginning of the study (Table 1). This is consistent with the previous studies using the ESR for disease surveillance [44, 71, 72]. In the mentioned research, the participants maintained their pre-experimental healthy status after the study period.

In addition to the widely investigated diabetes mellitus [7-10, 20, 31, 33-35, 45, 65] and cardiac diseases [12, 17, 21-23, 25, 28, 44], Ramadan fasting could also mitigate other disease conditions [8-10, 28]. Some of the diseases and

disease symptoms that could be improved by Ramadan fasting as reported in various studies in different regions include anemia [11, 12, 15, 21], metabolic dysfunction [42, 43], overweightness and obesity [42, 43], gastrointestinal dysfunction [42, 43, 73, 74], infertility [75-77], nearsightedness (myopia) [47, 78], stroke [36, 37], hypertension [79], and endocrine and renal diseases [7-10, 20, 24, 27, 30, 31, 43, 80, 81]. These studies have further strengthened the hypotheses of easy-to-perform [2], devoid-of-hazards Ramadan fasting in Muslim adherents and human participants [26, 31], confirming that this religious practice is immensely beneficial health-wise [28, 31] and socioculturally [5], while richly imbued with environmentally harmonious impacts [39].

Sociocultural and Environmental Importance

Ramadan fasting ensures togetherness, brings forth equity, strengthens love and affection, restores social justice, enhances brotherhood, facilitates the unity of people, and creates harmony in the society [1-6, 39]. Based on the Islamic principles, the usual activities of Ramadan common to all believers as the components of the monthly practice include fasting during the same month, waiting for the time to break the fast in the evening (*Iftar*), congregational *Tarawih* prayers observed in the mosque after breaking the fast with *Iftar* (evening meal), and waking at midnight for the pre-dawn meal (*Sahur*) [2, 3, 6]. All these practices help foster unity, brotherhood, and affection among believers. Ramadan fasting also entails various forms of deprivation. According to a writer, "A little self-deprivation inspires great compassion in us for the truly hungry people of the world." [39]. This has been illustrated in the books of Hadith by Allah's Messenger thus: The similitude of believers in regard to mutual love, affection, and fellow-feeling is that of one body; when any limb aches, the whole body aches because of sleeplessness and fever [3, 38]. Therefore, believers feel themselves to be the limbs of one body, and this feeling strengthens solidarity in homes and among family members and neighbors and also nurtures friendship in the entire community [39]. In addition, the Night of Power (*Laylat al-Qadr*) in the last 10 days of fasting and the *Eid* celebration (*Eid-el-Fitr*) at the end of Ramadan month strengthen the social ties earlier cultivated among believers and facilitate more

bonding, with the festivities assuming various merry-making dimensions in different Muslim countries [1, 4, 5].

As discussed earlier, Ramadan fasting positively changes the attitudes of people, especially Muslim adherents, toward each other and other fellow human beings. In fact, communal eating at dining tables by family members and even as a community in mosques is a global practice in the Muslim world. As opined by Muslim authors, the culture of Islam recommends that all family members sit at the table together for dining [1, 4, 6, 38]. Ramadan fasting brings this recommendation to the forefront as all the members of a family sit at the dining table together, waiting patiently for *Iftar* time. The practice of inviting relatives, friends, neighbors, and even strangers for *Iftar* (the meal taken to break the fast) is also highly recommended [4, 5]. There is mutuality as friends converge and wait together for the same event and experience the same feelings [6]. They feel tenderhearted toward each other, and in fact, toward all living beings because of the pang of hunger they feel [39]. They have neither the time nor the energy for enmity or grudges. These affectionate feelings continue after Ramadan for fasting is a period of training [1]. These are part of the sociocultural benefits of Ramadan fasting.

Ramadan fasting abolishes the barriers between the rich and the poor [39]. The sense of empathy that fasting evokes helps pious Muslims to understand other people's feelings better. Fasting raises the awareness of the situation of the poor and downtrodden in the society [5]. In Ramadan fasting, the feelings of hunger and thirst experienced by the rich, who normally eat nutritious and wholesome food and probably never suffer from the pangs of hunger, are lessons of great importance [39]. It is a natural phenomenon for the wealthy to think about the have-nots during this period, which elevates the desire of the rich to help the poor and needy as fasting makes it possible for them to empathize with the poor after having experienced the challenging conditions the less-privileged live in [5, 39]. The holy month of Ramadan facilitates the care for all strata of the society.

The social and communal benefits of Ramadan month cannot be over-emphasized. The provision of food for the care, welfare, and nourishment of all the members of the society enhances adequate manpower with improved

productivity. This is because hardly any tasks could be accomplished for optimal productivity by a group of poorly-fed people. This fact was established in a clinical study regarding the impact of the nutritional status on the cognitive performance of secondary school students in Zaria (northwestern Nigeria) [82]. The mentioned study indicated a positive correlation between the nutritional status of the students and their cognitive performance [82]. Furthermore, the study emphasized on the importance of adequate feeding for optimal performance in any set tasks. The provision of adequate nutrition is part of the goals of Ramadan fasting as the rich strive to give to the poor in the spirit of Ramadan. Clearly, there is deep wisdom in following these Islamic rules and carrying out such acts of benevolence that have many personal and social benefits, even if only some of these benefits have been made known to us.

As can be seen, abstinence from food in Ramadan fasting does not only make us healthy, but it also makes us a perfect member of the community. The Holy Prophet says in the books of Hadith that *"Those who are full while their neighbors are hungry are not of us."* [3, 38]. It is only common sense that none will want to be an outcaste, and everybody will be well nourished as the rich strives to cater for the poor in a bid to belong to the society. The poor will in turn reciprocate the rich's gesture of kindness and compassion with love and affection. Thus, they are less likely to feel or show envy, jealousy, and hatred toward those who are better off. The change of attitude on both sides of the social strata develops with the annulment of enmity, paving the way for peace and security. This positively impacts the community as harmony permeates the society [5, 6].

In the words of one Muslim environmentalist, Ramadan fasting improves the environmental outlook through the modification of human behaviors and life patterns [39]. The Holy Prophet Muhammad (SAW) was quoted thus: *"If someone tries to pick a quarrel with a Muslim who is fasting, he is to control himself and reply: I am fasting."* [3, 38]. This further emphasizes on the importance of peace, harmony, and tranquility in the society. Among the other environmental effects of Ramadan are the beneficial health effects through the loss of excess weight and controlling of the lipid profile owing to the

unavailability of food items during daytime in Ramadan [17, 26]. This is a common phenomenon, especially among the students living in hostels [29] and camp refugees [83]. The restoration of social justice, equity, security, peace, and tranquility in the society for the sociocultural balance of the community and environmental harmony cannot be over-emphasized as it is a worthwhile experience emanating from Ramadan.

Conclusion

One can conclude by aligning with the observation of easy-to-fulfill, devoid-of-hardship for the adherents of this religious obligation of Ramadan fasting. Furthermore, observing long-term intermittent fasting annually practised by Muslims during the holy month of Ramadan does not have any deleterious effects on the physical functions. Rather than being a culprit in the pathogenesis of diseases or aggravating poor health, fasting has been reported to be helpful in various conditions, such as body weight control, GIT relief, abating allergic reactions, and mitigating various human ailments (e.g., diabetes, anemia, atherosclerosis, acute coronary syndrome, and other cardiovascular diseases). In as much as the fasting of Ramadan is a blessing to the GIT of the participants in that it provides an annual physiological rest, there is the need to further investigate and obtain a mechanistic insight into the rationale behind this phenomenon. In addition to the health benefits of fasting, there are inherent personal, social, communal, and environmental benefits accruing from the Islamic practices of Ramadan. Therefore, the focus of the further investigations in this regard should be on the mechanisms facilitating various health benefits and system boosts in the human participants of Ramadan fasting.

One of the limitations of this review was that only a few of the studies reported using animal models subjected to food and water restrictions and extrapolated the results for use on humans. In as much as these experimental food denials of animals attempted to simulate human fasting, they cannot fully represent all the procedural steps involved in the religious fasting observed by Muslim adherents. As such, similar clinical studies involving human participants should be replicated in the future in order to obtain specific and direct results regarding the effects of

Ramadan fasting on humans regardless of deductions and extrapolations.

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